INVENTIONS & INNOVATION

Project Fact Sheet

TRIBOPOLYMERIZATION AS AN ANTI-WEAR MECHANISM

INNOVATIVE LUBRICATION TECHNOLOGY REDUCES WEAR AND FRICTION ON CERAMIC AND METAL SURFACES

Benefits

New anti-wear additives developed through the concept of tribopolymerization:

- Save energy by reducing friction in machining and cutting applications by approximately 40% and tool wear between 40% and 80%
- Reduce wear of a variety of materials, including ceramics, metals, and advanced alloys
- Contain no metals, phosphorus, or sulfur, and are often biodegradable; therefore they are likely to have minimal negative environmental effects
- Can be suitable for use as fuel lubricity additives in jet, diesel, and gasoline fuels
- May be customized for different locations
- Reduce fuel injector wear in natural gas engines
- Eliminate need for special delivery systems

Applications

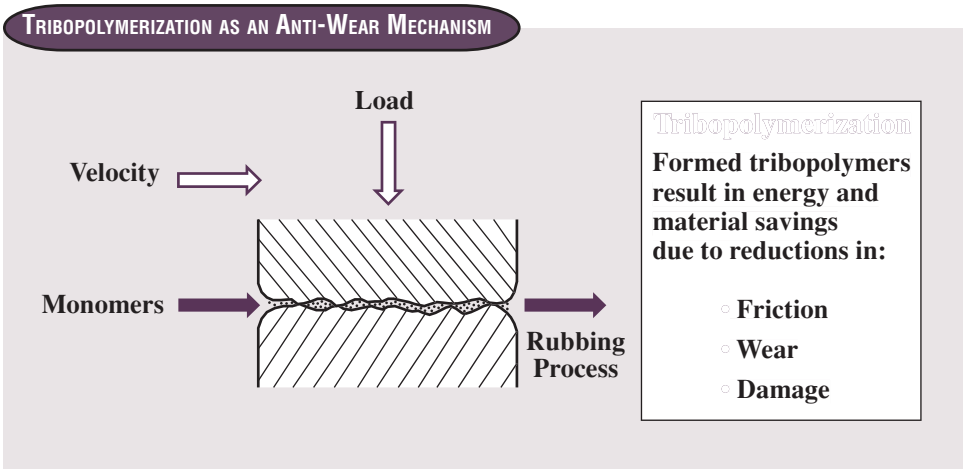
The invention benefits a wide range of industries, including the machine tool, aerospace, and both the heavy- and light-duty engine industries. It is useful as a lubricant for ceramic components and as an ashless anti-wear additive for automotive and aviation lubricants and fuels. It also shows promise as effective boundary lubrication in steel-on-steel, ceramic-on-ceramic, and steel-on-ceramic applications, which are used in a variety of industries.

Tribopolymerization is an advanced technology that uses molecules, called monomers, to create perpetually renewing films directly on surfaces that require lubrication, such as ceramic or alloy steel. Unlike the action of surface treatments or coatings, which wear away, these protective polymeric films form continuously in critical areas of boundary lubrication and wear. The films efficiently form in localized areas where the greatest amount of wear occurs, reducing wear and friction, and saving energy in the process.

This new technology offers a novel approach to improving lubrication and reducing wear in high-temperature ceramic engines and many other applications. Traditionally, it has been difficult to lubricate ceramic materials due to their different surface characteristics from metal, yet ceramics can operate in corrosive, high temperature environments that often cause damage to metal components. Conventional coating methods offer only short-term lubrication, but Virginia Polytechnic Institute's tribopolymerization concept results in continuous boundary lubrication over extended periods of time on multiple surfaces.

Project Description

Goal: The goal of the project was to carry out studies to demonstrate the merit of the concept of tribopolymerization under more severe conditions of load, speed, and frictional heat generation.



The tribopolymerization concept has led to the development of new classes of anti-wear additives, which reduce friction and wear in ceramic, metal, and advanced alloy applications.

The tribopolymerization concept led to the development of entirely new classes of compounds (additives), which are used at low concentrations in a carrier fluid – lubricant or gas – to reduce wear and surface damage under severe conditions of lubrication. The adsorbed monomer molecules on the solid surfaces polymerize under the conditions of rubbing contact, reacting with themselves to form a polymer chain, which acts as a protective film. This self-replenishing film reduces adhesion and wear on ceramic-on-ceramic, steel-on-steel, and ceramic-on-steel applications. Due to its ability to withstand high temperatures, the invention may serve as an enabling technology in the development of new engines and automotive propulsion systems.

Virginia Polytechnic Institute and State University developed this new technology with the help of a grant funded by the Inventions and Innovation Program through the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

- Several industrial applications for the process have been successfully tested.
- The inventor and his colleagues formed Tribochem International, Ltd., to further promote the technology in various market segments.
- A high-load, high-speed pin-on-disk machine was developed, allowing the development of new classes of monomers designed for higher temperature applications.
- The invention is protected by six U.S. patents.

Economics and Commercial Potential

The invention's market potential is diverse and results from a variety of cost, performance, energy, and environmental advantages. Commercial applications include:

- an ashless anti-wear or "lubricity" additive for fuels, including gasoline, diesel, and jet fuel
- the development of ashless lubricants for existing and future automotive engines to reduce environmental emissions
- the lubrication of ceramic engines (such as low-heat rejection diesel engines)
- machining and cutting applications using thin films to reduce friction and ceramic tool wear
- special minimalist pretreatment compositions for assembling and running-in engines
- vapor phase applications to high temperature gaseous systems or to fuel injector wear problems associated with the use of natural gas engines
- use of tribopolymerization as an enabling technology in the development of new engines and propulsion systems.

In some instances, the invention's market potential depends on the acceptability of ceramics in market segments, such as combustion engines, turbomachinery, and bearings. However, the use of ceramic tools in machining is already established. It is estimated that the market for ceramic wear parts could exceed $500 million in the year 2000.

The invention will have good market potential if it addresses lubrication between ceramic and metal interfaces, which have a market that is expected to grow in the future. These additional markets will likely increase the technology's value but the initial striking successes with steel systems demonstrate that tribopolymerization has broad applications. Under a licensing agreement with Virginia Tech Intellectual Properties, Inc., the company Tribochem International, Ltd. was formed in 1997. Tribochem International, Ltd. is involved in the design and production of anti-wear compounds and additives.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and to conduct early development. Ideas that have significant energy-savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

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